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TETRA TECH

MEMO

To:	[redacted], USAID OEGI Deputy Director, AESP Contracting Officer Representative
Cc:	[redacted], USAID Infrastructure Program Manager [redacted], USAID Stabilization Officer [redacted] USAID Project Manager – Energy and Water
From:	[redacted] AESP Acting Chief of Party
Date:	July 7, 2014
Subject:	Deh-Asodah Check Dam Concept Review

This memo addresses a request from USAID to Tetra Tech to review the proposed Deh-Asodah Check Dam concept package. This review provides a high-level conceptual review of the proposed Deh-Asodah Check Dam near Asodah Village, Maiwand District, Afghanistan.

Information Provided for Review

Information was provided by USAID for the conceptual review. In summary, the materials received included:

- Technical Drawing – Asodah Check Dam, 19 pages
- Environmental Review Form and Report – Draft, 7 pages
- Bill of Quantities, Excel spreadsheet
- Work Plan, Excel spreadsheet
- Design Calculations, Excel Spreadsheet
- Final Scope of Work – 4 pages
- Technical Specifications – 9 pages

Provided information was not dated; all information was considered to be a draft.

Summary of Review Findings

Based upon our review findings, Tetra Tech has several concerns with the proposed design and offers the following general comments regarding the suitability of the proposed Deh-Asodah Check Dam.

1. The intent of the check dam is to provide alluvial aquifer recharge to the karez network and therefore reduce the need for diesel pumping. No study has been provided that indicates that the dam will provide the intended recharge and alleviate the need for pumping.
2. No analysis has been provided of the safety and integrity of the proposed dam under various loading conditions which would allow us to assess the stability of the structure. Failure of the structure could have dire consequences downstream, but no assessment of the impacts was provided.
3. Numerous assumption were made regarding key design features such as soil properties, topography of the dam site and the impoundment area and flows associated with the design storm.
4. The Technical Specifications contain numerous vague references such as “best quality”, “coarse material”, and “adequate compaction”. The project specifications should identify the intended properties for materials and construction in a clear and indisputable manner; what is considered “adequate” or “best

quality" can vary greatly from one person to another. Clear direction for materials and construction is critical to the durability of the completed structure.

5. Several inconsistencies were noted in the Technical Specifications such as the use of both Fahrenheit and Celsius temperature references, apparent reference to an outdated Indian Standard Code for concrete strength and reference to material conformance to "specified requirements" that have not been provided.
6. The Final Scope of Work and the Technical Specifications contradict one another regarding the strength of concrete to be used for the cement and sand mortar and for the reinforced concrete slab.

Conclusion

Based on our review of the provided materials, Tetra Tech cannot confirm that the proposed Deh-Asodah Check Dam will perform its intended function of aquifer recharge and cannot determine if the structure will be structurally sound. At this time, Tetra Tech does not recommend that USAID proceed with the advertising and construction of the Deh-Asodah Check Dam until additional studies have been performed and a more comprehensive technical specification is prepared.

More comprehensive reviews were performed by our geotechnical and structural staff, and they are included here for your reference.

Geotechnical Review

Overall Concept

According to the draft *Environmental Review Form and Report*, the purpose of the check dam is to provide alluvial aquifer recharge to a karez network. The water table is too low to feed the karez network, requiring use of diesel pumps to withdraw water. The cost of operating the pumps necessitates cultivation of opium poppy. It was postulated that restoring water to the karez system would reduce the need for pumping and thus the need for opium cultivation.

The data available to Tetra Tech did not include a hydrogeologic investigation of the area of the check dam and karez groundwater regime. Tetra Tech has concerns that the construction of the check dam will not provide an adequate source of groundwater recharge to the karez system. For example, the karez is located a significant distance from the proposed impoundment, 200+ meters, and the change in elevation from the impoundment to the karez, estimated from Google Earth imagery, is on the order of 2 meters. Consequently, it is likely that groundwater will flow under or around the dam and continue to follow the normal groundwater downstream gradient, which is anticipated to follow the streambed and little, if any, groundwater would flow to the karez. A hydrogeologic study should be performed to evaluate the feasibility of the check dam recharge scheme. Specifically, a hydrogeologic study should include the following: Elevation of the water table, information on the elevation of the check dam and the karez system, distance of the karez from the check dam impoundment, and hydraulic conductivity of the rock and soil below and adjacent to the check dam and the impoundment.

Dam Safety Requirements

No dam safety performance requirements were specified for the proposed check dam. Dam structural performance criteria include, but are not limited to, stability under certain loads, seismic design, and hydrologic design requirements. These requirements should be defined to help ensure the long-term stability, operability, and safety of the dam. Dam failure is a significant risk that often results in lost lives.

Stability analyses for several loading conditions should be considered. Different conditions include normal loading conditions, flooding load conditions, seismic events, and a combination of those conditions. While some

stability calculations are presented in the Design Calculations, many notations are in Pashto/Dari and were unable to be translated for review.

The purpose of an emergency spillway on a dam is to provide a controlled location for excess flows to discharge downstream, reducing the risk of overtopping the dam, which is a primary cause of dam failure. No information was given regarding the emergency spillway capacity. There are no international standards or known Afghan regulations that govern spillway capacity requirements. In general, regulations for spillway capacity consider the risk to downstream structures and the potential for loss of life; i.e., the greater risk that is downstream necessitates a greater spillway capacity. No assessment of downstream risk was discussed in the documentation. A capacity for the emergency spillway design must be determined.

The design calculations do show an estimate for the spillway capacity. The design flow shown in the calculations appear to be determined using the designed size of the spillway. However, this is in reverse from the normal design procedure where the spillway is sized based upon the needed capacity. It is critical to determine the design flood in order to properly size the spillway. While regulations vary from jurisdiction to jurisdiction, design floods can vary from the 1% annual chance flood (also known as the 100-year flood) to the Probable Maximum Flood (PMF). The design flood should be selected in accordance with local regulations.

Data Requirements

Construction drawings appear to have been completed without the use of a topographic survey. A topographic survey of the site and the impoundment area is an important component of dam design. The topographic data at the dam site will provide more precise data that impacts the size of the dam and the quantity of materials. Topographic survey of the impoundment area can be used to calculate the maximum storage volume of the reservoir. The volume reported in the *Environmental Review Form and Report* was estimated from unknown data.

A geotechnical investigation should be conducted to evaluate the dam foundation and availability of suitable materials. An investigation should include drilling along the dam axis, the abutments, and under the energy dissipation structure. Investigation should include testing for engineering properties and soil permeability. Geologic mapping should be conducted in the vicinity of the dam and the impoundment and should include the karez. The investigation should evaluate the suitability of the site for dam construction. This information will also be utilized for the hydrogeologic study.

A flood hydrologic investigation should be conducted to determine the design flood for the structure. The design flood is a critical project element that impacts dam safety. Aerial photography shows that the watershed for the stream may be substantial, which implies that runoff volumes may also be substantial. The study should estimate the design flood for the spillway, as required by local regulations.

Dam Configuration

The dam is proposed to be constructed of stone masonry. It is assumed from the photos interspersed throughout the documentation that masonry will be constructed of local materials and be hand-placed by local labor. While technically feasible, masonry dams are not constructed in favor of modern dam construction practices. Hand-placed masonry is prone to leakage. Some leakage through hand-placed stone masonry can be mitigated if mortar is puddled well or if an upstream seal is placed. Consideration should be given to an alternative material or method for construction. Traditional construction methods include earth fill or concrete dams. If use of local stone and labor is a benefit for the dam, cyclopean masonry can be considered. Cyclopean masonry is a forerunner to a concrete dam and consists of rock rubble placed between confining walls with concrete poured into the pore spaces. The confining walls may be constructed of good quality masonry.

The wing walls and abutments of the dam are configured in a manner that is assumed to protect the upstream abutments to protect from erosion. This type of protection is likely unnecessary. However, the dam should have sufficient length constructed into the abutments to protect against erosion and water bypassing the dam.

No specifications are given for structural backfill on dam components. Backfill should be material that has a low conductivity. Investigation should be conducted to identify suitable materials for the backfill.

The cutoff wall underneath the dam could be replaced by a deepened keyway under the dam. This alternate configuration would require further investigation.

The construction drawings show that there are two low-level outlet works that penetrate the dam. No required release rates were defined in the documentation, so the pipe capacity could not be assessed. A potential cost savings could be realized by constructing only one low-level outlet works.

Some changes could be considered to the configuration of the low-level outlet works. In its current location, the outlet works is not accessible when flow is passing over the spillway. An alternate configuration would be to move the outlet works inlet to a location that is not underneath the spillway with a slide gate on the upstream end. This would allow for operation of the low-level outlet works from the crest of the dam.

If the low-level outlet works remains in its current location, then further waterproofing measures would be needed to prevent seepage from entering the vault through stone masonry walls. Cast-in-place concrete walls or a precast vault could be used to that end. The vault lid should also be lockable to prevent tampering, and secured to the dam to prevent it from washing away.

Outlet works pipe is called out as two different materials in the construction drawings: PVC or Polyethylene. No materials or performance criteria are given in the technical specifications. Pipe that penetrates the dam should be welded to ensure water tightness through the penetration. Concrete encasement of the pipe would provide additional protection against leaking pipe. The gate valve for this size of pipe may also be too large to fit in the vault. When finalizing design, the elevation of the rising stem must be compared to the ceiling elevation of the vault to prevent interference.

The stilling basin located downstream of the spillway is documented within the design calculations. However, notations are in Pashto/Dari and were not translated. Effectiveness of stilling basins is dependent upon the Froude number of flow within the basin and the configuration of the basin itself; one configuration may be appropriate for one scenario, but not another. After a design flow is selected, hydraulic modeling should be performed to determine the appropriate stilling basin configuration.

The stilling basin and spillway crest are proposed to be constructed of unreinforced concrete slabs. Due to the forces associated with high-velocity water, consideration should be given to anchoring the slabs in place. Moving water tends to generate an uplifting force. This uplift can be counteracted by the weight of the concrete and the weight of water above the panel. Calculations should be performed to evaluate uplift potential due to flowing water.

The retaining walls in the stilling basin are constructed of stone masonry. It is unknown what effect the flow turbulence within the stilling basin will have on the lifespan of the stone masonry walls. Consideration should be given to constructing the basin walls out of cast-in-place concrete.

There is no subsurface drainage system to collect seepage that will pass under the dam. A subsurface drainage system should be included.

Excavations for cutoff walls and foundations are proposed to be very steep (1H:4V). This is generally considered to be unsafe for excavations and will require additional shoring or protective measures.

Structural Review

Tetra Tech has performed a cursory review of the structural design for the subject dam. Most of the notes, terminology, comments, and callouts in the structural calculations are in the local language (not English), and were not translated. However, the theoretical parts of the structural calculations are performed in English and

somewhat understandable. With this limitation in mind, the following are some comments about few of the more critical aspects of the structural design:

1. Only a static load analysis and design is performed on this unreinforced stone masonry wall acting as a dam. Unreinforced stone masonry walls are in their nature brittle and highly susceptible to cracking, especially more so, in a seismic event. Seismic design must be performed.
2. The static wall stability analysis presented in the calculations indicate the bearing pressure in the soil below the stone masonry wall will be 189.73kPa (4 kips/sf). Since there is no geotechnical report, it cannot be verified that this is within the allowable bearing pressure limit for the soil.
3. It does not appear that the flexural and shear capacity calculations for the unreinforced stone masonry wall were checked.
4. Geotechnical design parameters such as soil's angle of internal friction (ϕ), coefficient of friction at bottom of wall (μ) and the unit weight of soil (γ) are used in the design but there is no geotechnical report to support them.
5. Gabions are used to retain earth in the wing walls, sometimes to significant height. Calculations do not include a stability check for these gabion earth retention systems.

Regarding the type of construction used, the water tightness of this type of construction, (unreinforced stone masonry walls) is, in general, not good and depends to a great degree on the skill of the laborer laying the stone blocks and on the quality control measures implemented in the construction process. Any minor imperfection in the mortar between the stone blocks might cause a leak which, with time, will cause further erosion of the mortar between the stones causing the leak to grow further.

The overall quality of the drawings is inconsistent and not in accordance with generally accepted standards. The line-work on some drawings overlaps with the text on the drawing causing some confusion and may impact the interpretation of the intent of the drawings. Also the text size on the drawing in general varies to a great degree and in some cases the text is very small and hard to read.

Given all the above issues Tetra Tech has reservations about the structural design and detailing for this dam.

End of Memo